

## ***Quercus trungkhanhensis* (Fagaceae), a New Species from Cao Vit Gibbon Conservation Area, Cao Bang Province, northeastern Vietnam**

HOANG THI BINH<sup>1,2,\*</sup>, NGUYEN VAN NGOC<sup>1,2</sup>, VU ANH TAI<sup>3</sup>, HOANG THANH SON<sup>4</sup>,  
SHUICHIRO TAGANE<sup>5</sup> AND TETSUKAZU YAHARA<sup>1,5</sup>

<sup>1</sup>Graduate School of Systems Life Sciences, Kyushu University, 744 Motoooka, Fukuoka, 819-0395, Japan.

\*binhht@dlu.edu.vn (author for correspondence); <sup>2</sup>Department of Biology, Dalat University, 01 - Phu Dong Thien Vuong, Dalat, Vietnam; <sup>3</sup>Institute of Geography, Vietnam Academy of Science and Technology, Hanoi, Vietnam;

<sup>4</sup>Silviculture Research Institute, Vietnamese Academy of Forest Sciences, Ha Noi, Vietnam; <sup>5</sup>Center for Asian Conservation Ecology, Kyushu University, 744 Motoooka, Fukuoka, 819-0395, Japan

A new species, *Quercus trungkhanhensis* Binh & Ngoc (Fagaceae), from Cao Vit Gibbon Conservation Area, northeastern Vietnam is described. It is morphologically similar to *Q. engleriana* Seemen and *Q. marlipoensis* Hu & Cheng in having scaly cupules and in the shape, texture and glabrescence of the leaves, but distinguished from the former particularly by the size and morphology of the fruits (acorns and cupules) and the latter by smaller leaves with fewer lateral veins. *Quercus trungkhanhensis* is also similar to *Q. franchetii* Skan in fruit morphology, but differs in having glabrescent leaves.

Key words: Cao Vit Gibbon Conservation Area, Fagaceae, new species, *Quercus*, Vietnam

*Quercus* Linnaeus (1753) (Fagaceae), with 400–500 species (Nixon 1993, Valencia-A *et al.* 2016), is one of the largest genera in the Fagaceae. The genus is characterized by pendulous staminate inflorescences, carpellate flowers always solitary, capitate or dilated stigma and indehiscent cupules (Huang *et al.* 1999, Phengklai 2008). Some species are often dominant in various forest types, including temperate deciduous forests in eastern North America, Europe and Asia, Mediterranean and desert scrub forest in Europe, Mexico and adjacent regions, and tropical montane forests in Southeast Asia (Nixon 1993, Hubert *et al.* 2014, Valencia-A *et al.* 2016). Besides their economic and ecological importance, species of *Quercus* are also considered in many countries as cultural and patrimonial resources (Hubert *et al.* 2014).

Vietnam is known for the high diversity of species of Fagaceae; 216 species in 6 genera, including 44 species of *Quercus* have been record-

ed (Ho 2003, Ban 2005, Li *et al.* 2016, Ngoc *et al.* 2016). Recently, taxonomic studies of Fagaceae in Vietnam have been undertaken by Deng *et al.* (2010), Linh *et al.* (2013), Vuong and Xia (2014), Li *et al.* (2016) and Ngoc *et al.* (2016), but the taxonomy of *Quercus* remains to be revised.

Here, we report a new species of *Quercus* from Cao Vit Gibbon Conservation Area, located at Trung Khanh District, Cao Bang Province, northeastern Vietnam (Fig. 1). The conservation area was established in 2007 to strengthen conservation for the Cao Vit gibbon (*Nomascus nasutus*) and covers 7,600 ha of limestone ground where five types of vegetation are found (Tu *et al.* 2009): subtropical evergreen broad leaved forests in valleys, subtropical bamboo forests in valleys, limestone subtropical evergreen mixed forests, tropical evergreen shrub savannahs and tropical secondary evergreen grasslands. Within the conservation area, 960 species of vascular plants, of which 34 species are listed as threatened in Viet-

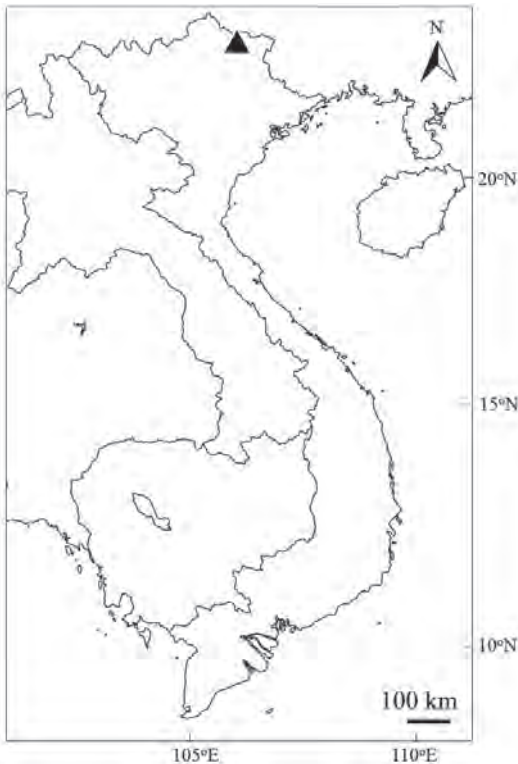


FIG. 1. Distribution map of *Quercus trungkhanhensis* Binh & Ngoc. Black triangle: Cao Vit Gibbon Area, Trung Khanh District, Cao Bang Province.

nam's Red Data Book (Ban *et al.* 2007, Tu *et al.* 2009), belonging to 144 families have been recorded.

During a botanical survey at Cao Vit Gibbon Conservation Area in 2016, we discovered an undescribed species of *Quercus*, based on morphological comparison with morphologically similar species, which we describe and illustrate below as *Quercus trungkhanhensis* Binh & Ngoc. We also provide DNA sequences of the two regions of ITS and *matK* for DNA barcoding, and assess its conservation status using IUCN Red List criteria (IUCN 2001).

## Material and Methods

### Morphological observations

To verify the validity of the new species, we thoroughly reviewed the literature (Camus 1936–

1954, Soepadmo 1972, Ho 1999, Huang *et al.* 1999, Ban 2005, Phengklai 2008) related to *Quercus* in Vietnam and surrounding countries. Based on the cupule morphology, *Quercus trungkhanhensis* is considered to be a member of subgenus *Quercus* (scale-cup oaks; Nixon 1993). According to the key in the Flora of China (Huang *et al.* 1999), *Q. trungkhanhensis* corresponds to *Q. engleriana* Seemen or *Q. marlipoensis* Hu & Cheng in the persistent leathery leaves with acute apex, cupule bracts scale-like, petiole 1–3 cm long, mature leaf blade abaxially glabrous or early glabrescent. According the acorn-based key in the Flora of Thailand (Phengklai 2008), *Q. trungkhanhensis* corresponds to *Q. franchetii* Skan in scaly cupule wall, cup-shaped cupule, each infructescence with (1 or)2 acorns, and serrate leaf margin. We therefore compared *Q. trungkhanhensis* with *Q. engleriana*, *Q. marlipoensis* and *Q. franchetii*. For morphological comparison, we examined specimens using the websites of JSTOR Global Plants (<http://plants.jstor.org>) and the Chinese Virtual Herbarium (hereafter CVH: <http://www.cvh.org.cn/>). We also examined more than two hundred dried specimens kept in the herbaria DLU, FU, HN, P and VNM.

### DNA barcoding

For DNA isolation, a piece of leaf was collected and desiccated using silica gel in the field. DNA was isolated by the CTAB method (Doyle & Doyle 1987) with minor modifications described in Toyama *et al.* (2015). We determined sequences of two DNA barcode regions; the internal transcribed spacer (ITS) and the large subunit of maturase K (*matK*) using the published protocols of Rohwer *et al.* (2009) and Dunning and Savolainen (2010) with a minor modification using Tks Gflex™ DNA Polymerase (TAKARA, Japan) in the PCR amplification.

### Phylogenetic analysis

We constructed a phylogenetic tree using nucleotide sequences of the DNA barcoding regions of ITS (487 bp) for 9 species including 8 species of *Quercus* and one species of *Lithocarpus* (Table

2). In addition to *Quercus trungkhanhensis*, we included *Q. engleriana*, *Q. franchetii* and three other species of subgenus *Quercus* for which ITS sequences were available in GenBank. No ITS sequence of *Q. marlipensis* was available in GenBank. Two species of *Quercus* subgenus *Cyclobalanopsis* and *Lithocarpus dahuoensis* Ngoc & L. V. Dung were used as outgroups. Sequence alignment was performed by ClustalW with default parameter implemented in MEGA v.7.0 (Kumar *et al.* 2016).

The Neighbor-joining method (Saitou & Nei 1987) with Maximum Composite Likelihood distance matrix (Tamura *et al.* 2004) implemented in MEGA v.7.0 was used to construct the phylogenetic tree. Confidence values for individual branches were determined by bootstrap analysis with 10,000 times resampling of the data.

## Results

The comparison of characters among *Quercus trungkhanhensis*, *Q. engleriana* and *Q. franchetii* is shown in Table 1. Among the four syntypes of *Q. engleriana* available on the webpage of JS-TOR Global Plants (*A. Henry 5682*, 1885–1888, China, BM, US and two specimens at GH), *A. Henry 5682A* (GH) is the only fruiting specimen. *Quercus trungkhanhensis* is distinct from *Henry 5682A* in the size and morphology of the mature fruits. The mature fruits of *A. Henry 5682A* (*Q. engleriana*) are 12.5–13 mm long, with cupules 3.8–5.5 mm tall and 8.5–10 mm wide, acorns 5–7 mm long above the cupule and 6.5–7.5 mm wide, and the stylopodium is ca. 2 mm long. In *Q. trungkhanhensis* the mature fruits are 16–22 mm long, with cupules 8–10 mm tall and 12–14 mm wide, acorns 8–12 mm long above the cupule and 10–12 mm wide, and the stylopodium is ca. 2 mm long. The acorns are ovoid and acute at apex in *Q. engleriana*, but cylindrical and slightly concave at apex in *Q. trungkhanhensis*. The cupules are cup-shaped and relatively loosely covered with scales on the lower half in *Q. engleriana* but more cylindrical and tightly covered with scales in *Q. trungkhanhensis* (Fig. 2D–F). There are many

images of *Q. engleriana* in CVH in showing the above distinctions to be mostly stable. As for fruit morphology of *Q. engleriana*, PE00297544 [Nanchuan, Chongqing, alt. 1750 m, 6 Oct. 1957, *J.-H. Xiong & Z.-L. Zhou 93826* (PE): <http://www.cvh.org.cn/spm/PE/00297544>] has exceptionally more cylindrical acorns but the acorns are less than 10 mm long, as in typical *Q. engleriana*. In *A. Henry 5682A*, the fruiting branchlets have 12 terminal or lateral buds that are narrowly ovoid, 5–9 mm long and 3–6 mm wide, whereas in *Q. trungkhanhensis* the buds are broadly ovoid, 3–4 mm long and 2–3 mm wide (Fig. 2A, Fig. 3B). The shape of the narrowly ovoid buds is stable among specimens of *Q. engleriana* in CVH. The young branchlets of *Q. trungkhanhensis* are appressed hairy with yellowish brown hairs (Fig. 2A), but the branchlets of *Q. engleriana* are yellowish gray tomentose. *Quercus trungkhanhensis* is also distinct from *Q. engleriana* in having nearly glabrous leaves on fruiting branchlets; *Q. engleriana* usually retains dense hairs along the abaxial veins and on the petioles. According to the images on the CVH website, hairiness of the leaves of fruiting branchlets is somewhat variable, but *Q. engleriana* retains dense hairs at least in the vein axils.

The digital images of the holotype (PE00039496) of *Quercus marlipensis* available on the CVH webpage shows much larger leaves with more lateral veins (leaf blade 12–22 × 6–11 cm, with 11–16 pairs of lateral veins) than *Q. trungkhanhensis* (leaf blade 9–15 × 2–5 cm, with 8–10 pairs of lateral veins) and *Q. engleriana*. Among four specimens of *Quercus marlipensis* at PE, PE00022946 (<http://www.cvh.org.cn/spm/PE/00022946>) has three cupules which are 13–15 mm wide and larger than those of *Q. engleriana* (8.5–10 mm wide) and as large as *Q. trungkhanhensis* (12–14 mm wide). In PE00022946 the buds are narrowly ovoid (12 × 7 mm) as in *Q. engleriana*. In all four specimens the leaves and petioles are almost glabrous as in *Quercus trungkhanhensis* and the branchlets are less hairy than in *Quercus trungkhanhensis* and *Q. engleriana*.

Six images of syntypes of *Quercus franchetii*

TABLE 1. Morphological comparison between *Quercus trungkhanhensis* Binh & Ngoc, sp. nov. with *Quercus engleriana* Seemen, *Quercus franchetii* Skan and *Q. marlipoensis* Hu & Cheng. Descriptions of fruit characters are based on mature fruits.

Characters	<i>Q. trungkhanhensis</i>	<i>Q. engleriana</i>	<i>Q. marlipoensis</i>	<i>Q. franchetii</i>
Buds shape	Broadly ovoid	Narrowly ovoid <sup>(1)</sup>	Narrowly ovoid	Narrowly ovoid <sup>(4)</sup>
Twigs	Yellowish brown appressed stellate hairy	Yellowish gray tomentose <sup>(2)</sup>	Yellowish brown tomentose <sup>(2)</sup>	Yellowish gray simple and fascicled hairs <sup>(2)</sup>
Leaf margin	Serrate upper (4/5–)2/3	Serrate upper 1/2, sometime entire <sup>(2)</sup>	Scattered teeth or entire and slightly inflexed <sup>(2)</sup>	Serrate upper 1/2, setaceous at ends of teeth <sup>(2), (3)</sup>
Leaf surface	Glabrous on both surfaces except midrib and lateral veins	Densely yellowish brown pubescent <sup>(2)</sup>	Abaxially stellate tomentose along midvein <sup>(2)</sup>	Glabrous on the upper surface; densely yellowish gray tomentose below in the lower <sup>(4)</sup>
Leaf base	Rounded or shallowly cordate	Rounded, broadly cuneate, or rarely shallowly cordate <sup>(2)</sup>	Rounded <sup>(2)</sup>	Cuneate to cordate or obtuse <sup>(2), (3)</sup>
Leaf size	(7–)9–12.5 × 2.4–5.8 cm	6–16 × 2.5–5.5 cm <sup>(2)</sup>	12–22 × 6–11 cm <sup>(2)</sup>	5–12 × 2.5–6 cm <sup>(2)</sup>
Length of petioles	1.8–2.4 cm long	1–2 cm long <sup>(2)</sup>	1.5–3 cm <sup>(2)</sup>	0.2–1.4 cm long <sup>(3), (4)</sup>
Number of secondary veins	8–10 pairs	10–13 pairs <sup>(2)</sup>	16–20 pairs <sup>(2)</sup>	6–9 pairs <sup>(3), (4)</sup>
Cupule size	8–10 mm tall, 12–14 mm in diam.	3.8–5.5 mm tall, 8.5–10 mm in diam. <sup>(1)</sup>	8 mm tall, 14 mm in diam. <sup>(2)</sup>	(4–)7–12 mm tall, 10–14 mm in diam. <sup>(2)</sup>
Scales of cupule	Triangular	Ovate–lanceolate <sup>(1)</sup>	Ovate <sup>(2)</sup>	Triangular <sup>(2)</sup>
Nut enclosure	Enclosing 1/3–1/2 of the nut	Enclosing 1/3–1/2 of the nut <sup>(2)</sup>	N/A	Enclosing 1/2 of the nut <sup>(2)</sup>
Apex of nut	Truncate and slightly concave	Acute <sup>(1)</sup>	N/A	Slightly concave <sup>(3), (4)</sup>
Infructescence	1–1.5 cm long, each infructescence with ( 1 or )2 acorns	1–5 cm long, each infructescence with 1–10 acorns <sup>(2)</sup>	N/A	1–5 cm long, each infructescence with ( 1 or )2 acorns <sup>(3)</sup>

<sup>(1)</sup> From the material *A. Henry 5682* (GH)

<sup>(2)</sup> From the description in flora of China (Huang *et al.* 1999)

<sup>(3)</sup> From the description in flora of Thailand (Phengklai 2008)

<sup>(4)</sup> From the material *A. Henry 9298* (K)

are on the webpage of JSTOR Global Plants [*Henry A 9298*, Yunnan, China, A(2), K(2), NY, US]. *Quercus trungkhanhensis* is easily distinguished from *Q. franchetii* by having nearly glabrous leaves on the fruiting branchlets (vs. densely yellowish gray tomentose on the lower surface). Among the six syntypes, two specimens (A and K) have mature fruits have cup-shaped, somewhat cylindrical cupules 8–9 mm and tightly covered with scales and cylindrical acorns 10–

12 mm long and 8–9 mm wide and slightly concave at the apex.

The Neighbor-joining tree base on ITS (Fig. 4) showed that *Quercus trungkhanhensis* is sister to *Q. franchetii* with 67% bootstrap probability and *Q. engleriana* is sister to those two species with 77% bootstrap probability. *Quercus trungkhanhensis* differed from *Q. franchetii* in four nucleotides and from *Q. engleriana* in ten nucleotides.

TABLE 2. List of taxa used in this study with GenBank accession number for the sequence of ITS region.

Subgenus	Species	GenBank accession no.
Subg. <i>Quercus</i>	<i>Quercus acutissima</i> Carruth.	AF098428
	<i>Quercus engleriana</i> Seemen	AY040465
	<i>Quercus franchetii</i> Skan	AY040464
	<i>Quercus griffithii</i> Hook. f. & Thomson ex Miq.	AY040490
	<i>Quercus variabilis</i> Blume	AY040463
Subg. <i>Cyclobalanopsis</i>	<i>Quercus myrsinifolia</i> Blume	AF098414
	<i>Quercus lamellosa</i> Sm.	AY040454
Outgroup	<i>Lithocarpus dahuaiensis</i> Ngoc & L. V. Dung	KY436002

## Taxonomy

### *Quercus trungkhanhensis* Binh & Ngoc, sp. nov. — Figs. 2–3.

*Quercus trungkhanhensis* is morphologically similar to *Q. engleriana* and *Q. maripoensis*, both distributed in China, in having persistent leaves, acuminate leaf apex, cupules covered with scales, petiole 1–3 cm long, mature leaf blades abaxially glabrous or early glabrescent, and leaf blade leathery; *Q. trungkhanhensis* differs from *Q. maripoensis* in having smaller leaves, and differs from *Q. engleriana* in having larger cupule, nuts cylindrical slightly concave at apex (vs. nuts ovoid and acute at the apex), larger cupules tightly covered with scales (vs. relatively sparsely covered with scales on basal half), broadly ovoid buds (vs. narrowly ovoid), and yellowish brown appressed hairy branchlets when young (vs. yellowish gray tomentose).

*Typus.* VIETNAM. Cao Bang Province, Trung Khanh District, limestone subtropical evergreen mixed forests of Cao Vit Gibbon Conservation Area, 22°54'55"N, 106°31'28"E, alt. 767 m, 6 Nov. 2016, *Binh HT, Ngoc NV, Tai VA, Son HT V6066* (holo- KYO!, iso- DLU!, FU!).

*Description.* Tree, 5–10 m tall, 15 cm in girth. Bark pale gray, deeply longitudinally furrowed. Buds broadly ovoid, ca. 3–4 mm long, ca. 2–3 mm in diam.; scales in 4–6 rows, imbricate, ovate-triangular, ca. 3 × 2.5 mm, apex obtuse, margin ciliate, appressed hairy on both surfaces. Twigs densely yellowish brown stellate hairy when young, later glabrescent, lenticellate.

Leaves alternate; petiole 1.8–2.4 cm long, densely yellowish brown hairy when young, glabrescent later; blade leathery, ovate or ovate-elliptic, (7–)9–12.5 × 2.4–5.8 cm, base rounded or shallowly cordate, margin serrate in upper (4/5–)2/3, apex acuminate, pale brown or reddish brown when dry, both surfaces glabrous except stellate hairs remaining near base of midrib on upper surface and in axils of secondary veins on lower surface; midrib slightly raised on upper surface, prominently raised on lower surface; lateral veins 8–10 pairs, prominent, at angle of 50–60(–70) degree from midrib, straight and running into marginal teeth, tertiary veins scalariform, faintly visible. Inflorescences (staminate and carpellate) not seen. Infructescences axillary or terminal, erect; peduncle woody, ca. 1 cm long; rachis 1–1.5 cm long, 4–5 mm in diam., glabrous, brownish red when fresh, blackish brown when dried, lenticellate. Mature fruits 1.6–2.2 cm long (including cupule), solitary or paired, sessile; acorns ovoid, 1–1.5 cm long, 1–1.2 cm in diam., truncate and slightly concave at apex, white tomentose when young, densely appressed hairy around stylopodium, stylopodium to 2 mm long, basal scar 5–6 mm in diam., raised; cupules cup-shaped, somewhat cylindrical, 0.8–1 cm tall, 1.2–1.4 cm in diam., enclosing 1/3 to 1/2 of the mature acorn, scales on cupule triangular, ca. 1–1.5 mm long on lower part of cupule, smaller on upper part, apex short acuminate or rarely acute, dull greenish yellow.



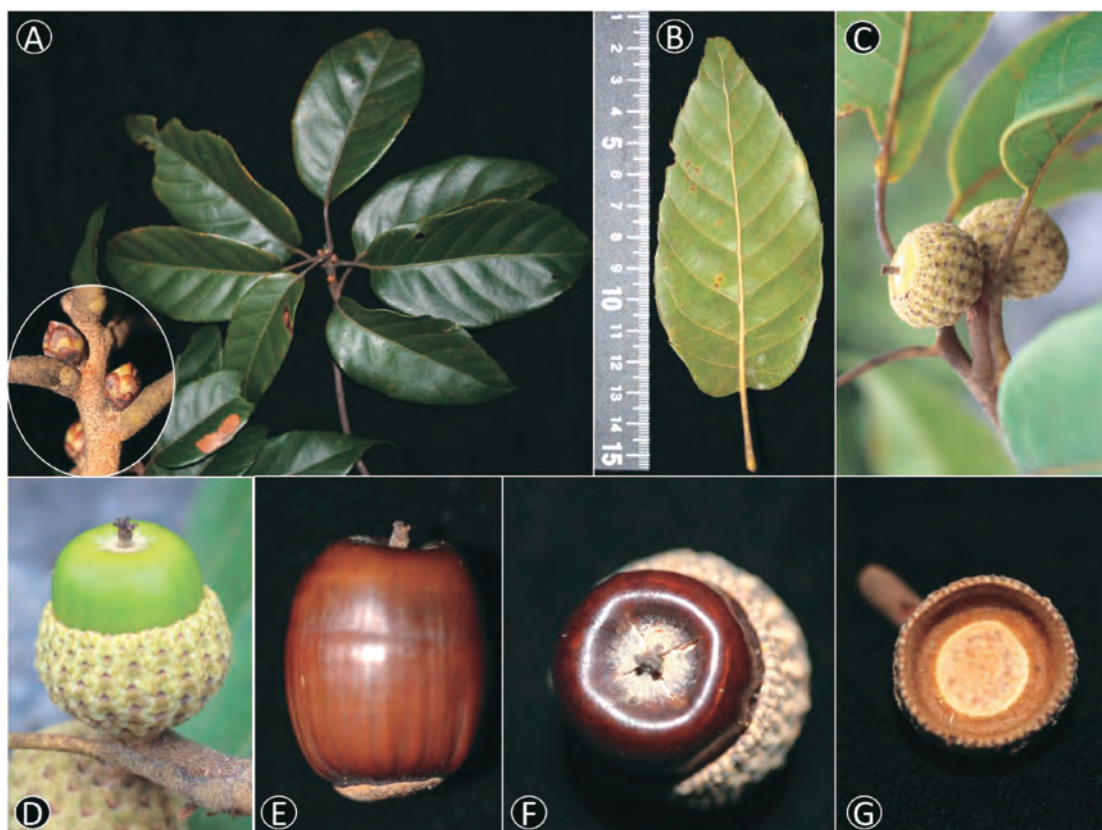


FIG. 2. *Quercus trungkhanhensis* Binh & Ngoc (Binh *et al.* V6066). A. Leafy twig and buds, B. Abaxial surface of mature leaf, C. Inflorescence and young fruits, D. Mature fruit, E. Nut (lateral view), F. Nut (top view), G. Inside of cupule.

low, dark purplish red near apex, densely appressed hairy with short grayish brown hairs outside, densely hairy with short yellowish brown hairs inside.

*Phenology.* Fruiting specimens were collected in January.

*Distribution and habitat.* Known only from Cao Vit Gibbon Conservation Area, Trung Khanh District, Cao Bang province, Vietnam (Fig. 1). We found only two individuals within 100 m<sup>2</sup> on a ridge in a limestone subtropical evergreen mixed forest, at 767 m altitude.

*Etymology.* The specific epithet is derived from the district name of the type locality, Trung Khanh District, Cao Bang Province, northeastern Vietnam.

*GenBank accession no.* Binh *et al.* V6066: KY867547 (ITS), LC258443 (*matK*).

*Conservation status.* Critically endangered (CR). *Quercus trungkhanhensis* is known only from two individuals. The forest in the Conservation Area is currently protected under law from anthropogenic activities but the locality of *Q. trungkhanhensis* was disturbed by local people searching for forest resources. Although additional individuals/populations of *Q. trungkhanhensis* may be discovered, it qualifies as CR under criterion B in that the area of occupancy is less than 10 km<sup>2</sup> at only a single location and criterion D of the population size is fewer than 50 mature individuals (IUCN 2001).

*Note.* *Quercus trungkhanhensis* is a member of *Quercus* subgenus *Quercus* (scale-cup oaks;

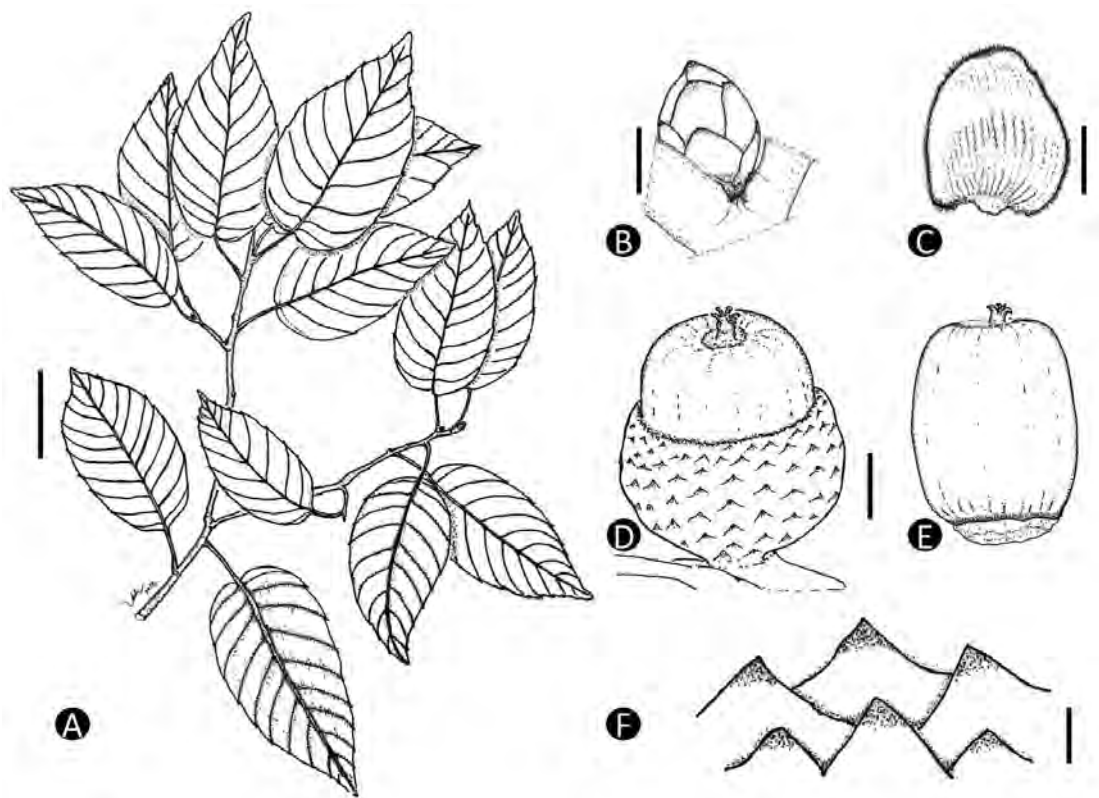


FIG. 3. Line drawing of *Quercus trungkhanhensis* Binh & Ngoc (Binh *et al.* V6066). A. Leafy twig, B. Bud, C. Bud scale, D. Mature fruit, E. Nut, F. Cupule scales. Scale bars A = 5 cm, B = 2 mm, C = 1 mm, D & E = 5 mm, F = 1 mm.

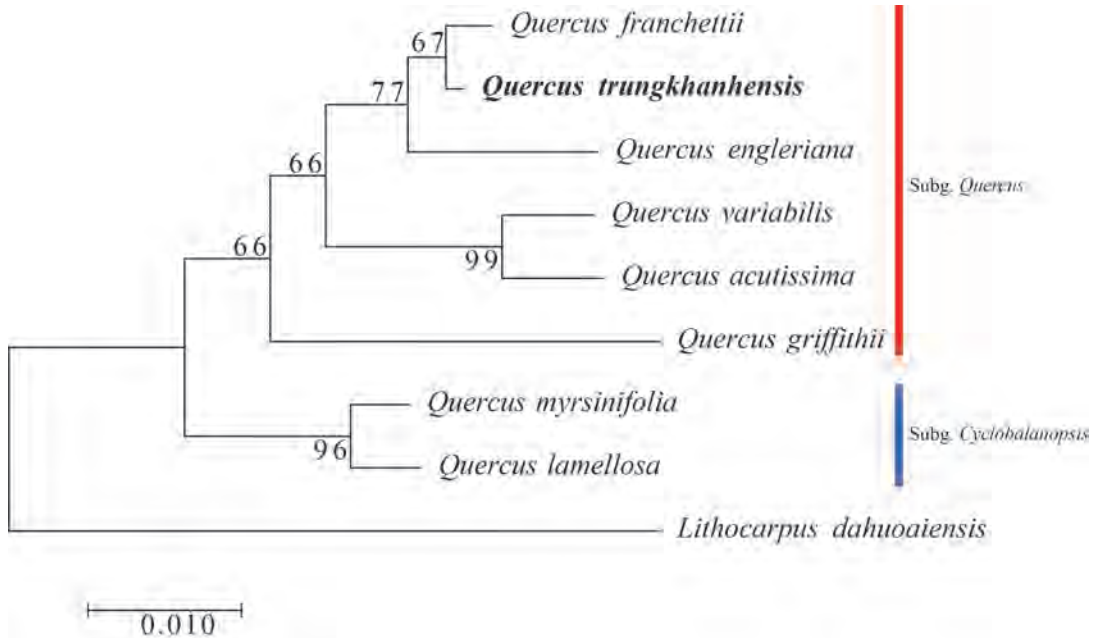


FIG.4. NJ tree of *Quercus trungkhanhensis* and seven species of subgenus *Quercus* and subgenus *Cyclobalanopsis* based on data from nuclear ribosomal ITS region. Branches are labeled with bootstrap support (% of 10,000 replicates)

Nixon 1993), corresponding to *Quercus* s. str., excluding *Cyclobalanopsis* (Huang *et al.* 1999). In Thailand (Phengklai 2008), most species of *Quercus* belong to subgenus *Cyclobalanopsis* (cycle-cup oaks; Nixon 1993). Phengklai (2008) listed only seven species of subgenus *Quercus*. Similarly, in Vietnam there are fewer species of subgenus *Quercus* than of subgenus *Cyclobalanopsis*. *Quercus trungkhanhensis* is easily distinguished from the eight other species of subgenus *Quercus* (*Q. acutissima* Carruth., *Q. aliena* Blume, *Q. franchetii*, *Q. kingiana* Craib, *Q. lanata* Sm., *Q. oblongata* D. Don, *Q. setulosa* Hickel & A. Camus and *Q. variabilis* Blume) in the leathery mature leaves abaxially glabrous or early glabrescent.

We thank our colleagues in the Institute of Geography, Vietnam Academy of Science and Technology, for their help in collecting samples in the field. Our gratitude goes to the curators and staff of the following herbaria DLU, FU, HN, P, VNM for making their materials accessible. This study was supported by the Environment Research and Technology Development Fund (S9 & 4-1601) of the Ministry of the Environment, Japan, and JSPS KAKENHI (15H02640).

## References

- Ban, N. T. 2005. Vietnam plant checklist. vol. 2. Agriculture Publishers, Hanoi National University, pp. 261–270. (in Vietnamese).
- Ban, N. T., D. T. Ly, N. Tap, V. V. Dung, N. N. Thin, V. N. Tien & K. N. Khoi. 2007. Vietnam Red Book Part II. Plants. Natural Sciences and Technology Publishers, Hanoi. (in Vietnamese).
- Camus, A. 1936–1954. Les Chênes. Monographie du genre *Quercus* et Monographie du genre *Lithocarpus*. Paul Lechevalier, Paris.
- Deng, M., Z. K. Zhou & A. Coombes. 2010. Lectotypification and New Synonymy in *Quercus* subg. *Cyclobalanopsis* (Fagaceae). *Novon* 20: 400–405.
- Doyle, J. J. & J. L. Doyle. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochem. Bull.* 19: 11–15.
- Dunning, L. T. & V. Savolainen. 2010. Broad-scale amplification of *matK* for DNA barcoding plants, a technical note. *Bot. J. Linn. Soc.* 164: 1–9.
- Ho, P. H. 2003. An Illustrated Flora of Vietnam, vol. 2, pp. 655–666. Young Publishers, Ho Chi Minh. (in Vietnamese).
- Huang, C. J., Y. T. Zhang & B. Bartholomew. 1999. Fagaceae. In: Wu, Z. Y., P. H. Raven & D. Y. Hong (eds.), *Flora of China*, vol. 4, pp. 333–369. Science Press, Beijing & Missouri Botanical Garden Press, St. Louis.
- Hubert, F., G. W. Grimm, E. Joussetin, V. Berry, A. Franc & A. Kremer. 2014. Multiple nuclear genes stabilize the phylogenetic backbone of the genus *Quercus*. *Syst. Biodiver.* 12: 405–423.
- IUCN. 2001. IUCN Red List categories and criteria: version 3.1. IUCN, Gland, Switzerland and Cambridge. <<http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria>> [accessed April 1, 2017].
- Kumar, S., G. Stecher & K. Tamura. 2016. MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. *Molec. Biol. Evol.* 33: 1870–1874.
- Li, Q., J. Zhang & A. Coombes. 2016. *Quercus lineata* (Fagaceae): new distribution records from China and Vietnam and its leaf anatomical features. *Phytotaxa* 266: 226–230.
- Linh, D. T., N. T. Anh, N. T. Cuong, D. V. Hai & D. T. Hoan. 2013. Basis of taxonomy for *Lithocarpus* Blume (Fagaceae Dumort.) in Vietnam. *Proceeding of 5th National conference on Ecology and Biological resources*, pp. 127–131. Institute of Ecology and Biological resources, Hanoi. (in Vietnamese).
- Linnaeus, C. 1753. *Species Plantarum*, 2. Stockholm.
- Ngoc, N. V., L. V. Dung, S. Tagane, H. T. Binh, H. T. Son, V. Q. Trung & T. Yahara. 2016. *Lithocarpus dahuoiensis* (Fagaceae), a new species from Lam Dong Province, Vietnam. *PhytoKeys* 69: 23–30.
- Nixon, K. C. 1993. Infrageneric classification of *Quercus* (Fagaceae) and typification of sectional names. *Ann. Sci. Forest.* 50: 25s–34s.
- Phengklai, C. 2008. Fagaceae. In: Santisuk, T. & Larsen, K. (eds.) *Flora of Thailand*, vol. 9, pp. 179–410. The Forest Herbarium, National Park, Wildlife and Plant Conservation Department, Bangkok.
- Rohwer, J. G., J. Li, B. Rudolph, S. A. Schmidt, H. van der Werff & H.-W. Li. 2009. Is *Persea* (Lauraceae) monophyletic? Evidence from nuclear ribosomal ITS sequences. *Taxon* 58: 1153–1167.
- Saitou N. & M. Nei. 1987. The neighbor-joining method: A new method for reconstructing phylogenetic trees. *Molec. Biol. Evol.* 4: 406–425.
- Soepadmo, E. 1972. Fagaceae. *Flora Malesiana*, series 1, Spermatophyta, vol. 7, part 2, pp. 265–403. Wolters-Noordhoff, Groningen, Netherlands. [Reproduced online. <<http://www.biodiversitylibrary.org/item/91160>>].
- Tamura, K., M. Nei & S. Kumar. 2004. Prospects for inferring very large phylogenies by using the neighbor-joining method. *Proc. Natl. Acad. Sci. U. S. A.* 101: 11030–11035.
- Toyama, H., T. Kajisa, S. Tagane, K. Mase, P. Chhang, V. Samreth, V. Ma, H. Sokh, R. Ichihashi, Y. Onoda, N.



- Mizoue & T. Yahara. 2015. Effects of logging and recruitment on community phylogenetic structure in 32 permanent forest plots of Kampong Thom, Cambodia. *Philos. Trans., Ser. B.* 370: 20140008.
- Tu, N. H., V. A. Tai, P. T. Vinh & T. T. T. Van. 2009. Plant diversity in Trung Khanh Nature Reserve, Cao Bang Province. Proceedings of the 3rd national scientific conference on ecology and biological resources. (in Vietnamese).
- Valencia-A, S., J. L. S. Rosales & O. J. S. Arellano. 2016. A new species of *Quercus*, section *Lobatae* (Fagaceae) from the Sierra Madre Oriental, Mexico. *Phytotaxa* 269: 120–126.
- Vuong, D. H. & N. H. Xia. 2014. Two new species in *Castanopsis* (Fagaceae) from Vietnam and their leaf cuticular features. *Phytotaxa* 186: 29–41.

*Received May 22, 2017; accepted July 7, 2017*